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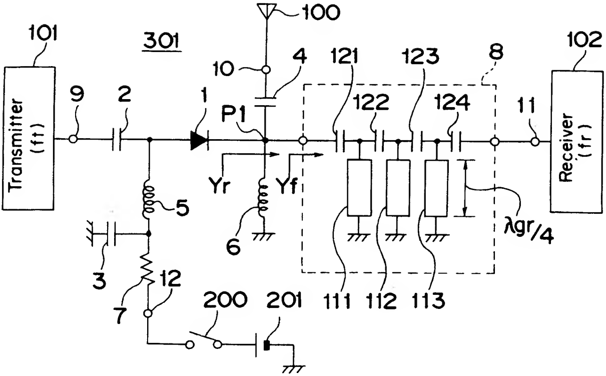
(54) **Antenna switching apparatus selectively connecting antenna with transmitter or receiver.**

(57) In an antenna switching apparatus for selectively connecting an antenna (100) through an antenna terminal (10) with either a transmitter (101) for transmitting a transmitting signal having a transmitting frequency through a transmitting terminal (9), or a receiver (102) for receiving a receiving signal having a receiving frequency different from the transmitting frequency through a receiving terminal (11), a receiving filter (8, 23) for passing therethrough a receiving signal is electrically connected between the antenna terminal (10) and the receiving terminal (11). An impedance adjusting element (6, 21, 32) is electrically connected with an input end of the receiving filter (8, 23), and has such an element value that an impedance when seen from the antenna terminal (10) toward the receiving filter (8, 23) becomes substantially infinity at the transmitting frequency. Further, a switching device (1, 38a, 46 and 38) is electrically connected between the antenna terminal (10) and the transmitting terminal (9), and is switched over in response to a control signal so that an impedance when seen from the antenna terminal (10) toward the transmitting terminal (9) becomes either substantially infinity or substantially zero.

Fig.1b


100
101
301
10
4
121
123
8
102
9
2
1
P1
122
124
11
Transmitter (ft)
Receiver (fr)
Yr
Yf
5
6
λgr/4
3
12
7
200
201
111
112
113

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an antenna switching apparatus for use in a radio transceiver such as a digital portable radio telephone or the like, and more particular, to an antenna switching apparatus comprising means for selectively connecting an antenna with either a transmitter or a receiver.

2. Description of the Prior Art

Fig. 8 shows a conventional antenna switching apparatus 300.

Referring to Fig. 8, an anode electrode of a PIN diode 70 is electrically connected through a coupling capacitor 74 with a transmitting terminal 79 which is electrically connected with a transmitter 101 having a transmitting frequency ft, and is also electrically connected through a high-frequency choke circuit comprising an inductor 78 and a capacitor 75 with ground. A cathode electrode of the PIN diode 70 is electrically connected through strip lines 73 and 83 and a coupling capacitor 77 with a receiving terminal 81 which is electrically connected with a receiver 102 having a receiving frequency fr, wherein each of the strip lines 73 and 83 has a length of $\lambda gt/4$ where λgt is the guide wavelength of the transmitting frequency ft.

Further, the cathode electrode of the PIN diode 70 is electrically connected through a coupling capacitor 76 to an antenna terminal 80 which is electrically connected with an antenna 100. A connection point between the two strip lines 73 and 83 is electrically connected through anode and cathode electrodes of a PIN diode 71 with ground, and a connection point between the strip line 83 and the coupling capacitor 77 is electrically connected through anode and cathode electrodes of a PIN diode 72 with ground. Furthermore, a connection point between the inductor 78 and the capacitor 75 is electrically connected with a bias terminal 82 which is electrically connected through a switch 200 with a battery 201 for supplying a positive direct-current bias voltage to the PIN diodes 70 to 72 for use as a switching device.

An action of the antenna switching apparatus 300 constituted as described above will be described hereinafter.

First of all, in the case where the switch 200 is turned off, namely, a positive direct-current bias voltage is not applied to the bias terminal 82, the PIN diodes 70 to 72 are turned off, and then the impedance of each of the PIN diodes 70 to 72 becomes substantially infinity. Therefore, the impedance when seen from the antenna terminal 80 toward the transmitting terminal 79 becomes substantially infinity, and then the transmitting terminal 79 is electrically separated from the antenna terminal 80 while the antenna terminal 80 is electrically connected with the receiving terminal 81.

On the other hand, in the case where the switch 200 is turned on, namely, the positive direct-current bias voltage is applied from the battery 201 through the switch 200 to the bias terminal 82, the PIN diodes 70 to 72 are turned on, and then the impedance of each of the PIN diodes 70 to 72 becomes substantially zero. Then, the connection point between the two strip lines 73 and 83 is electrically connected through the PIN diode 71 of a short-circuit with ground. Therefore, the phase at the antenna terminal 80 is shifted by a quarter of the guide wavelength of the transmitting frequency ft by the strip line 73, and then, it is earthed. This results in that the impedance when seen from the antenna terminal 80 toward the receiving terminal 81 becomes substantially infinity. Accordingly, the receiving terminal 81 is separated at high-frequencies from the antenna terminal 80. On the other hand, since the PIN diode 70 is turned on, the transmitting terminal 79 is electrically connected with the antenna terminal 80.

In the above-mentioned conventional antenna switching apparatus 300, in order to obtain a higher isolation characteristic between the transmitting and receiving terminals 79 and 81 so that the transmitting frequency characteristic is not influenced by the frequency characteristic of the receiver 102, it is necessary to provide a multi-stages of strip lines and PIN diodes between the antenna terminal 80 and the receiving terminal 81. Then, the length of the strip lines becomes longer, and the antenna switching apparatus becomes larger. Further, when providing multi-stages of strip lines and PIN diodes, the insertion loss between the antenna terminal 80 and the receiving terminal 81 increases. Therefore, in order to obtain a better receiving frequency characteristic, it is necessary to provide a large-sized receiving filter having a small insertion loss between the receiving terminal 81 and the antenna terminal 80, resulting in a large-sized antenna switching apparatus.

SUMMARY OF THE INVENTION

An object of the present invention is therefore to provide a small-sized antenna switching apparatus capable of selectively connecting an antenna with either transmitter or a receiver, said antenna switching apparatus having a simpler structure which includes a receiving filter for passing therethrough a receiving signal therein.

In order to achieve the aforementioned objective, according to one aspect of the present invention, there is provided an antenna switching apparatus for selectively connecting an antenna with either a transmitter for transmitting a transmitting signal having a transmitting frequency, or a receiver for receiving a receiving signal having a receiving frequency different from said transmitting frequency, comprising:

an antenna terminal electrically connected with said antenna;

a transmitting terminal electrically connected with said transmitter;

a receiving terminal electrically connected with said receiver;

a receiving filter, electrically connected between said antenna terminal and said receiving terminal, for passing therethrough a receiving signal;

an impedance adjusting element electrically connected with an input end of said receiving filter, said impedance adjusting element having such an element value that an impedance when seen from said antenna terminal toward said receiving filter becomes substantially infinity at said transmitting frequency; and

a switching device electrically connected between said antenna terminal and said transmitting terminal, said switching device being switched over in response to a control signal so that an impedance when seen from said antenna terminal toward said transmitting terminal becomes either substantially infinity or substantially zero.

In the above-mentioned antenna switching apparatus, said impedance adjusting element is an inductor electrically connected between the input end of said receiving filter and ground.

In the above-mentioned antenna switching apparatus, said impedance adjusting element is an inductor electrically connected between the input end of said receiving filter and said antenna terminal.

In the above-mentioned antenna switching apparatus, said impedance adjusting element is a transmission line connected between the input end of said receiving filter and said antenna terminal, said transmission line having such a length that an impedance when seen from said antenna terminal toward said receiving filter becomes substantially infinity at said transmitting frequency.

The above-mentioned antenna switching apparatus preferably further comprises a low-pass filter electrically connected between said antenna terminal and said receiving filter, said low-pass filter having a cut-off frequency equal to a sum obtained by adding a higher frequency among said transmitting and receiving frequencies to a predetermined margin frequency.

The above-mentioned antenna switching apparatus preferably further comprises a low-pass filter electrically connected between said antenna terminal and said switching device, said low-pass filter having a cut-off frequency equal to a sum obtained by adding said transmitting frequency to a predetermined margin frequency.

The above-mentioned antenna switching apparatus preferably further comprises a low-pass filter electrically connected between said transmitting terminal and said switching device, said low-pass filter having a cut-off frequency equal to a sum obtained by adding said transmitting frequency to a predetermined margin frequency.

In the above-mentioned antenna switching apparatus, said switching device is a PIN diode.

In the above-mentioned antenna switching apparatus, said switching device is an field effect transistor.

In the above-mentioned antenna switching apparatus, said switching device includes:

a further transmission line electrically connected between said antenna terminal and said transmitting terminal, said further transmission line having a length of a quarter of the guide wavelength of the receiving frequency; and

a switching component electrically connected between said transmitting terminal and ground, said switching component being turned on or off in response to said control signal, thereby switching over so that the impedance when seen from said antenna terminal toward said transmitting terminal becomes either substantially infinity or substantially zero, respectively.

According to the present invention, there can be provided a small-sized antenna switching apparatus capable of selectively connecting an antenna with either transmitter or a receiver, said antenna switching apparatus having a simpler structure and a higher performance which includes a receiving filter for passing therethrough a receiving signal therein.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects and features of the present invention will become clear from the following description taken in conjunction with the preferred embodiments thereof with reference to the accompanying drawings throughout which like parts are designated by like reference numerals, and in which:

Fig. 1a is a top plan view of an antenna switching apparatus 301 of a first preferred embodiment according to the present invention;

Fig. 1b is a circuit diagram of the antenna switching apparatus 301 shown in Fig. 1a;

Fig. 2a is a top plan view of an antenna switching apparatus 302 of a second preferred embodiment according to the present invention;

Fig. 2b is a bottom plan view of an antenna switching apparatus 302 shown in Fig. 2a;

Fig. 2c is a circuit diagram of the antenna switching apparatus 302 shown in Figs. 2a and 2b;

Fig. 3a is a top plan view of an antenna switching apparatus 303 of a third preferred embodiment according to the present invention;

Fig. 3b is a circuit diagram of the antenna switching apparatus 303 shown in Fig. 3a;

Fig. 4a is a top plan view of an antenna switching apparatus 304 of a fourth preferred embodiment according to the present invention;

Fig. 4b is a circuit diagram of the antenna switching apparatus 304 shown in Fig. 4a;

Fig. 4c is a circuit diagram of an antenna switching apparatus 304a of a first modification of the fourth preferred embodiment according to the present invention;

Fig. 4d is a circuit diagram of an antenna switching apparatus 304b of a second modification of the fourth preferred embodiment according to the present invention;

Fig. 4e is a circuit diagram of an antenna switching apparatus 304c of a third modification of the fourth preferred embodiment according to the present invention;

Fig. 5a is a top plan view of an antenna switching apparatus 305 of a fifth preferred embodiment according to the present invention;

Fig. 5b is a bottom plan view of an antenna switching apparatus 305 shown in Fig. 5a;

Fig. 5c is a circuit diagram of the antenna switching apparatus 305 shown in Figs. 5a and 5b;

Fig. 6 is a circuit diagram of an antenna switching apparatus 306 of a sixth preferred embodiment according to the present invention;

Fig. 7a is a perspective view of an antenna switching apparatus 307 of a seventh preferred embodiment according to the present invention;

Fig. 7b is a circuit diagram of the antenna switching apparatus 307 shown in Fig. 7a; and

Fig. 8 is a circuit diagram of a conventional antenna switching apparatus 300.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments according to the present invention will be described below with reference to the attached drawings.

In the preferred embodiments, each of the antenna switching apparatuses of the preferred embodiments is provided for selectively connecting an antenna 100 with either a transmitter 101 having a transmitting frequency ft or a receiver 102 having a receiving frequency fr, wherein the transmitting frequency ft is not equal to the receiving frequency fr.

FIRST PREFERRED EMBODIMENT

Fig. 1a is a top plan view of an antenna switching apparatus 301 of a first preferred embodiment according to the present invention. In Fig. 1a, the same components as those shown in Fig. 8 are denoted by the same references as those shown in Fig. 8.

Referring to Fig. 1a, electrically conductive electrode patterns 14a to 14h are formed on a top surface of a dielectric substrate 13. An anode electrode of a PIN diode 1 for use as a switching device is electrically connected through the electrode pattern 14a with one end of a coupling chip capacitor 2 and one end of an air-core inductor 5, and another end of the coupling chip capacitor 2 is electrically connected through the electrode pattern 14e with a transmitting terminal 9 which is electrically connected with the transmitter 101 for transmitting a transmitting signal having a transmitting frequency ft.

Another end of the air-core inductor 5 is electrically connected through the electrode pattern 14b with one end of a chip capacitor 3 and one end of a chip resistor 7, wherein another end of the chip capacitor 3 is electrically connected through the electrode pattern 14c with ground, and another end of the chip resistor

7 is electrically connected through the electrode pattern 14h with a bias terminal 12 which is electrically connected through a switch 200 with a positive electrode of a battery 201 having a negative electrode electrically connected with ground.

Further, a cathode electrode of the PIN diode 1 is electrically through the electrode pattern 14d with not only respective one ends of a coupling chip capacitor 4 and an air-core inductor 6 but also an input end of a plane type dielectric receiving band-pass filter 8 having a pass-band for passing therethrough a receiving signal having the receiving frequency fr. Another end of the air-core inductor 6 is electrically connected through the electrode pattern 14c with ground. Another end of the coupling chip capacitor 4 is electrically connected through the electrode pattern 14f with an antenna terminal 10 which is electrically connected with the antenna 100. Furthermore, an output end of the receiving band-pass filter 8 is electrically connected through 14g with the receiving terminal 11 which is electrically connected with the receiver 102 for receiving a receiving signal having a receiving signal fr.

In the receiving band-pass filter 8, four capacitors 121 to 124 are electrically connected in series to each other between both the input and output ends thereof. A connection point between the two capacitors 121 and 122 is electrically connected through a strip line 111 having a length of $\lambda gr/4$ with ground, a connection point between the two capacitors 122 and 123 is electrically connected through a strip line 112 having a length of $\lambda gr/4$ with ground, and a connection point between the two capacitors 123 and 124 is electrically connected through a strip line 113 having a length of $\lambda gr/4$ with ground, wherein λgr is a guide wavelength of the receiving frequency fr.

In the antenna switching apparatus 301, when the admittance Yf when seen from the input end of the receiving band-pass filter 8 toward the output end thereof is represented by $Yf = G + jB$ where $G \fallingdotseq 0$ at the transmitting frequency ft, the inductance L of the air-core inductor 6 is predetermined so as to satisfy the following equation at the transmitting frequency ft:

$$B = 1/(\omega L) \quad (1),$$

where $\omega = 2\pi(ft)$.

Therefore, the admittance Yr when seen from the connection point P1 among the PIN diode 1, the coupling capacitor 4 and the air-core inductor 6 toward the receiving band-pass filter 8 is represented at the transmitting frequency ft by the following equation:

$$\begin{aligned} Yr &= 1/j\omega L + Yf \\ &= 1/j\omega L + G + jB \qquad (2). \end{aligned}$$

Substituting the equation (1) into the equation (2) obtains the following equation:

$$Yr = G \fallingdotseq 0$$
at the transmitting frequency ft (3).

Fig. 1b is a circuit diagram of the antenna switching apparatus 301 shown in Fig. 1a. An action of the antenna switching apparatus 301 will be described in detail hereinafter with reference to Fig. 1b.

First of all, in the case where the switch 200 is turned off, namely, a positive direct-current bias voltage is not applied to the bias terminal 12, the PIN diode 1 is turned off, and then the impedance of the PIN diode 1 becomes substantially infinity. Therefore, the impedance when seen from the antenna terminal 10 toward the transmitting terminal 9 becomes substantially infinity, and then the transmitting terminal 9 is electrically separated from the antenna terminal 10 while the antenna terminal 10 is electrically connected at the receiving frequency fr with the receiving terminal 11.

On the other hand, in the case where the switch 200 is turned on, namely, the positive direct-current bias voltage is applied from the battery 201 through the switch 200 to the bias terminal 12, the PIN diode 1 is turned on, and then the impedance of the PIN diode 1 becomes substantially zero. As is apparent from the equation (3), since the air-core inductor 6 is electrically connected with the connection point P1, the admittance Yr when seen from the connection point P1 or the antenna terminal 10 toward the receiving band-pass filter 8 becomes substantially zero at the transmitting frequency ft, namely, the impedance when seen from the connection point P1 toward the receiving band-pass filter 8 becomes substantially infinity at the transmitting frequency ft. Therefore, the receiving terminal 11 is electrically separated at the transmitting

frequency ft from the antenna terminal 10 while the transmitting terminal 9 is electrically connected with the antenna terminal 10 since the PIN diode 1 is turned on.

According to the first preferred embodiment, since the impedance when seen from the antenna terminal 10 toward the receiving band-pass filter 8 becomes substantially infinity at the transmitting frequency ft, the transmitting frequency characteristic is not influenced by the frequency characteristic of the receiver 102, and then it is not necessary to provide any multi-stage band-pass filter, resulting in not only less insertion loss between the antenna terminal 10 and the receiving terminal 11 but also improvement in the isolation characteristic between the transmitting and receiving terminals 9 and 11, as compared with the conventional antenna switching apparatus 300 shown in Fig. 8. Further, as is apparent from Figs. 1a and 1b, the smaller-sized antenna switching apparatus 301 having a simpler circuit can be easily obtained as compared with the conventional antenna switching apparatus 300.

In the first preferred embodiment, the PIN diode 1 is used as a switching device, however, the present invention is not limited to this. For example, an FET (Field Effect Transistor) may be used.

SECOND PREFERRED EMBODIMENT

Fig. 2a is a top plan view of an antenna switching apparatus 302 of a second preferred embodiment according to the present invention, and Fig. 2b is a bottom plan view of an antenna switching apparatus 302 shown in Fig. 2a. In Figs. 2a and 2b, the same components as those shown in Figs. 1a, 1b and 8 are denoted by the same references as those shown in Figs. 1a, 1b and 8.

Referring to Fig. 2a, electrically conductive electrode patterns 16a to 16c and 17a to 17g are formed on a top surface of a dielectric substrate 23, and an electrically conductive electrode pattern 18 is formed on a bottom surface of the dielectric substrate 23. The components 1, 2, 3, 5 and 7 are electrically connected through the electrode patterns 17a to 17g with the terminals 9, 10 and 12, in a manner similar to that of the first preferred embodiment.

Fig. 2c is a circuit diagram of the antenna switching apparatus 302 shown in Figs. 2a and 2b.

As is apparent from comparison between the first and second preferred embodiments respectively shown in Figs. 1b and 2c, there are further provided (a) an air-core inductor 21 and (b) a dielectric coaxial receiving band-pass filter 23 in the second preferred embodiment, which will be described in detail hereinafter.

Referring to Fig. 2a, one end of the air-core inductor 21 is electrically connected through the electrode pattern 17d with one end of the coupling capacitor 4, and another end of the air-core inductor 21 is electrically connected through the electrode pattern 16a with an input end of the receiving band-pass filter 23.

The receiving band-pass filter 23 is provided between the air-core inductor 21 and the receiving terminal 11 for passing therethrough the receiving signal having the receiving frequency fr, and comprises not only three capacitors 122 to 124 connected in series to each other but also three dielectric coaxial resonators 111a, 112a and 113a each having a length of $\lambda gr/4$.

A space on the dielectric substrate 15 formed between the electrode patterns 16a and 16b constitutes the capacitor 122, and a space on the dielectric substrate 15 formed between the electrode patterns 16b and 16c constitutes the capacitor 123. Further, the dielectric substrate 15 provided between the electrode patterns 16c and 18 constitutes the capacitor 124. Thus, there are electrically connected three capacitors 122 to 124 between both the input and output ends of the receiving band-pass filter 23.

The electrode pattern 16a of the input end of the receiving band-pass filter 23 is electrically connected through the dielectric coaxial resonator 111a with ground, the electrode pattern 16b of the connection point between the two capacitors 122 and 123 is electrically connected through the dielectric coaxial resonator 111b with ground, and the electrode pattern 16c of the connection point between the two capacitors 123 and 124 is electrically connected through the dielectric coaxial resonator 111c with ground.

In the antenna switching apparatus 302, when the impedance Zf when seen from the input end of the receiving band-pass filter 23 toward the output end thereof is represented by $Zf = R + jx$ where $R \fallingdotseq \infty$ at the transmitting frequency ft, the inductance L of the air-core inductor 21 is predetermined so as to satisfy the following equation at the transmitting frequency ft:

$$X = -\omega L \quad (4).$$

Therefore, the impedance Zr when seen from the connection point P1 among the PIN diode 1, the coupling capacitor 4 and the air-core inductor 21 toward the receiving band-pass filter 23 is represented at the transmitting frequency ft by the following equation:

$$Zr = j\omega L + Zf$$
$$= j\omega L + R + jX \qquad (5).$$

Substituting the equation (4) into the equation (5) obtains the following equation:

$Zr = R \fallingdotseq \infty$
at the transmitting frequency ft (6).

An action of the antenna switching apparatus 302 will be described in detail hereinafter with reference to Fig. 2c.

First of all, in the case where the switch 200 is turned off, namely, a positive direct-current bias voltage is not applied to the bias terminal 12, the PIN diode 1 is turned off, and then the impedance of the PIN diode 1 becomes substantially infinity. Therefore, the impedance when seen from the antenna terminal 10 toward the transmitting terminal 9 becomes substantially infinity, and then the transmitting terminal 9 is electrically separated from the antenna terminal 10 while the antenna terminal 10 is electrically connected at the receiving frequency fr with the receiving terminal 11.

On the other hand, in the case where the switch 200 is turned on, namely, the positive direct-current bias voltage is applied from the battery 201 through the switch 200 to the bias terminal 12, the PIN diode 1 is turned on, and then the impedance of the PIN diode 1 becomes substantially zero. As is apparent from the equation (3), since the air-core inductor 21 is electrically connected as an input coupling component with the connection point P1, the impedance Zr when seen from the connection point P1 or the antenna terminal 10 toward the receiving band-pass filter 23 becomes substantially infinity at the transmitting frequency ft. Therefore, the receiving terminal 11 is electrically separated at the transmitting frequency ft from the antenna terminal 10 while the transmitting terminal 9 is electrically connected with the antenna terminal 10 since the PIN diode 1 is turned on.

The antenna switching apparatus 302 according to the second preferred embodiment has the effects similar to those of the first preferred embodiment. In addition to these effects, since the bias current is flowed from the air-core inductor 21 through the dielectric coaxial resonator 111a with ground, it is not necessary to provide one capacitor 121 of the receiving band-pass filter 8 as compared with the first preferred embodiment. This results in that the smaller-sized antenna switching apparatus 302 having a simpler circuit can be easily obtained as compared with the antenna switching apparatus 300 and 301.

THIRD PREFERRED EMBODIMENT

Fig. 3a is a top plan view of an antenna switching apparatus 303 of a third preferred embodiment according to the present invention. In Fig. 3a, the same components as those shown in Figs. 1a, 1b, 2a, 2b, 2c and 8 are denoted by the same references as those shown in Figs. 1a, 1b, 2a, 2b, 2c and 8.

Referring to Fig. 3a, electrically conductive electrode patterns 25a to 25i and an electrically conductive electrode pattern 26 for use as microstrip lines 31 and 32 connected in series to each other are formed on a top surface of a dielectric substrate 24, and earthed electrically conductive electrode patten (not shown) is formed on the whole area of the bottom surface of the dielectric substrate 24. The components 1, 2, 3, 5 and 7 are electrically connected through the electrode patterns 25a to 25c, 25i and 25f with the terminals 9, 10 and 12, in a manner similar to that of the first preferred embodiment.

Fig. 3b is a circuit diagram of the antenna switching apparatus 303 shown in Fig. 3a.

As is apparent from comparison between the first and third preferred embodiments respectively shown in Figs. 1b and 3b, there are further provided

(a) an air-core inductor 28 for flowing a bias current therethrough instead of the air-core inductor 6 of the first preferred embodiment;

(b) a microstrip line 32 having a length $\ell e1$; and

(c) a low-pass filter 33 comprising a microstrip line 31 and two capacitors 27 and 29, which will be described in detail hereinafter.

Referring to Fig. 3a, the microstrip lines 31 and 32 connected in series to each other are constituted by the electrode pattern 26. One end of the air-core inductor 28 is electrically connected through the middle point on the electrode patten 26 corresponding to the connection point P1 with the cathode electrode of the PIN diode 1 and one end of the low-pass filter 33, while another end of the air-core inductor 28 is

electrically connected through the electrode pattern 25e with ground. Another end of the low-pass filter 33 is electrically connected through one end of the electrode pattern 26 with one end of the capacitor 4. Another end of the microstrip line 32 is electrically connected with the input end of the receiving band-pass filter 8.

In the low-pass filter 33, the microstrip line 31 has a length of $\lambda ga/4$ where λga is the guide wavelength of a cut-off frequency fc of the low-pass filter 33 equal to a sum obtained by adding a higher frequency among the transmitting and receiving frequencies ft and fr to a predetermined margin frequency.

In the antenna switching apparatus 302, when the impedance Zf when seen from the input end of the receiving band-pass filter 8 toward the output end thereof is represented by $Zf = R + jX$ where $R \fallingdotseq \infty$ at the transmitting frequency ft, the length $\ell e1$ of the microstrip line 32 is predetermined so that the impedance Zr when seen from the connection point P1 toward the receiving band-pass filter 8 becomes substantially infinity by rotating the phase at the connection point P1 by the following angle θ at the transmitting frequency ft about the center of the Smith chart:

$$\theta = \tan^{-1} (X / R) \qquad (7).$$

An action of the antenna switching apparatus 303 will be described in detail hereinafter with reference to Fig. 3b.

First of all, in the case where the switch 200 is turned off, namely, a positive direct-current bias voltage is not applied to the bias terminal 12, the PIN diode 1 is turned off, and then the impedance of the PIN diode 1 becomes substantially infinity. Therefore, the impedance Zt when seen from the antenna terminal 10 toward the transmitting terminal 9 becomes substantially infinity, and then the transmitting terminal 9 is electrically separated from the antenna terminal 10 while the antenna terminal 10 is electrically connected at the receiving frequency fr with the receiving terminal 11.

On the other hand, in the case where the switch 200 is turned on, namely, the positive direct-current bias voltage is applied from the battery 201 through the switch 200 to the bias terminal 12, the PIN diode 1 is turned on, and then the impedance of the PIN diode 1 becomes substantially zero. As described above, since the microstrip line 32 is electrically connected as an input coupling component between the connection point P1 and the input end of the receiving band-pass filter 8, the impedance Zr when seen from the connection point P1 toward the receiving band-pass filter 8 becomes substantially infinity at the transmitting frequency ft. Therefore, the receiving terminal 11 is electrically separated at the transmitting frequency ft from the antenna terminal 10 while the transmitting terminal 9 is electrically connected with the antenna terminal 10 since the PIN diode 1 is turned on.

The antenna switching apparatus 303 according to the third preferred embodiment has the effects similar to those of the first preferred embodiment. In addition to these effects, since the low-pass filter 33 is provided between the coupling capacitor 4 and the connection point P1, unnecessary high-order higher harmonics having frequencies higher than the cut-off frequency fc of the low-pass filter 33 can be sufficiently suppressed upon transmitting and receiving, resulting in improvement in the high-order higher harmonics characteristic in both the transmitting and receiving.

In the third preferred embodiment, the microstrip lines 31 and 32 are used, however, the present invention is not limited to this. Transmission lines such as strip lines, coplanar lines or the like may be used in stead of the microstrip lines 31 and 32.

FOURTH PREFERRED EMBODIMENT

Fig. 4a is a top plan view of an antenna switching apparatus 304 of a fourth preferred embodiment according to the present invention. In Fig. 4a, the same components as those shown in Figs. 1a, 1b, 2a, 2b, 2c, 3a, 3b and 8 are denoted by the same references as those shown in Figs. 1a, 1b, 2a, 2b, 2c, 3a, 3b and 8.

Referring to Fig. 4a, not only electrically conductive electrode patterns 35a to 35f and 37 but also electrically conductive electrode patterns 36a, 36b and 36c respectively for use as microstrip lines 111, 112 and 113 each acting as microstrip line resonator are formed on a top surface of a dielectric substrate 34. Also, an electrically conductive earthed electrode patten (not shown) is formed on the whole area of the bottom surface of the dielectric substrate 34. The components 4, 8 and 32 are electrically connected with the terminals 10 and 11, in a manner similar to that of the third preferred embodiment.

Fig. 4b is a circuit diagram of the antenna switching apparatus 304 shown in Fig. 4a. As is apparent from comparison between the third and fourth preferred embodiments respectively shown in Figs. 3b and 4b, there are further provided

(a) a microstrip line 46 having a length of λgr/4 where λgr is the guide wavelength of the receiving frequency fr;

(b) a coupling capacitor 39;

(c) an N channel FET 38 for use as a switching device;

(d) an air-core inductor 45 for a high-frequency choke circuit; and

(e) a capacitor 41 for the high-frequency choke circuit, which will be described in detail hereinafter.

Referring to Fig. 4a, the microstrip lines 46 and 32 connected in series to each other are constituted by the electrode pattern 37. The middle point of the electrode pattern 37 located at the connection point P1 is electrically connected through the microstrip line 46 and the coupling capacitor 39 with the transmitting terminal 9, and a connection point located at one end of the electrode pattern 37 between the microstrip line 46 and the capacitor 39 is electrically connected with a source electrode of the FET 38. A drain electrode of the FET 38 is electrically connected through the electrode pattern 35a with ground, and a gate electrode thereof is electrically connected through the electrode pattern 35b and the air-core inductor 45 with the bias terminal 12, which is electrically connected through the capacitor 41 and the electrode pattern 35a with ground.

An action of the antenna switching apparatus 304 will be described in detail hereinafter with reference to Fig. 4b.

First of all, in the case where the switch 200 is turned on, namely, a positive direct-current bias voltage is applied to the bias terminal 12, the FET 38 is turned on, and then the impedance between the source and drain electrodes of the FET 38 becomes substantially zero, and then the one end of the microstrip line 46 on the side of the capacitor 39 is electrically connected through the FET 38 of a short-circuit with ground. This results in that the phase at another end of the microstrip line 46 is shifted by λgr/4 by the microstrip line 46, and thereafter is electrically connected through the FET 38 with ground. Therefore, the impedance Zt when seen from the antenna terminal 10 toward the transmitting terminal 9 becomes substantially infinity, and then the transmitting terminal 9 is electrically separated from the antenna terminal 10 while the antenna terminal 10 is electrically connected at the receiving frequency fr with the receiving terminal 11.

On the other hand, in the case where the switch 200 is turned off, namely, the positive direct-current bias voltage is not applied from the battery 201 through the switch 200 to the bias terminal 12, the FET 38 is turned off, and then the impedance between the source and drain electrodes of the FET 38 becomes substantially infinity. Further, as described above, since the microstrip line 32 is electrically connected as an input coupling component with the connection point P1, the impedance Zr when seen from the connection point P1 or the antenna terminal 10 toward the receiving band-pass filter 8 becomes substantially infinity at the transmitting frequency ft. Therefore, the receiving terminal 11 is electrically separated at the transmitting frequency ft from the antenna terminal 10 while the transmitting terminal 9 is electrically connected with the antenna terminal 10 since the FET 38 is turned off.

The antenna switching apparatus 304 according to the fourth preferred embodiment has the effects similar to those of the third preferred embodiment.

In the fourth preferred embodiment, the microstrip lines 32 and 46 are used, however, the present invention is not limited to this. Transmission lines such as strip lines, coplanar lines or the like may be used in stead of the microstrip lines 32 and 46.

Further, as shown in Fig. 4c showing an antenna switching apparatus 304a of a first modification of the fourth preferred embodiment according to the present invention, as compared with the fourth preferred embodiment shown in Fig. 4b, there may be provided the air-core inductor 21 and the receiving band-pass filter 23 of the second preferred embodiment, respectively, in stead of the microstrip line 32 and the receiving band-pass filter 8.

Further, as shown in Fig. 4d showing an antenna switching apparatus 304b of a second modification of the fourth preferred embodiment according to the present invention, as compared with the fourth preferred embodiment shown in Fig. 4b, there may be provided an N channel FET 38a for use as a switching device in stead of the microstrip line 46. In this case, a gate electrode of the FET 38a is electrically connected through the air-core inductor 45 with the bias terminal 12, which is electrically connected through the capacitor 41 with ground. In the second modification, an electrical connection between the antenna terminal 10 and the transmitting terminal 9 is switched over by the FET 38a.

Furthermore, as shown in Fig. 4e showing an antenna switching apparatus 304c of a third modification of the fourth preferred embodiment according to the present invention, in the above-mentioned second modification, there may be provided the air-core inductor 21 and the receiving band-pass filter 23 of the second preferred embodiment, respectively, in stead of the microstrip line 32 and the receiving band-pass filter 8.

FIFTH PREFERRED EMBODIMENT

Fig. 5a is a top plan view of an antenna switching apparatus 305 of a fifth preferred embodiment according to the present invention, and Fig. 5b is a bottom plan view of an antenna switching apparatus 305 shown in Fig. 5a. In Figs. 5a and 5b, the same components as those shown in Figs. 1a, 1b, 2a, 2b, 2c, 3a, 3b, 4a to 4e and 8 are denoted by the same references as those shown in Figs. 1a, 1b, 2a, 2b, 2c, 3a, 3b 4a to 4e and 8.

Referring to Fig. 5a, electrically conductive electrode patterns 53a to 53c, 54 and 55a to 55g are formed on a top surface of a dielectric substrate 34. On the other hand, an earthed electrically conductive electrode patten 57 is formed on a part of the bottom surface of the dielectric substrate 34, and further, an electrically conductive electrode patten 56 is formed on another part of the bottom surface of the dielectric substrate 34. The components 39, 46, 41, 45, 38, 4, 21 and 23 are electrically connected with the terminals 9 to 12, in a manner similar to that of the first modification of the fourth preferred embodiment shown in Fig. 4c.

Fig. 5c is a circuit diagram of the antenna switching apparatus 305 shown in Figs. 5a and 5b. As is apparent from comparison between the fifth preferred embodiment and the first modification of the fourth preferred embodiment respectively shown in Figs. 4c and 5c, there are further provided two capacitors 58 and 59, respectively, at both ends of the microstrip line 46 of the electrode pattern 54 having a length of $\lambda gr/4$ where λgr is the guide wavelength of the receiving frequency fr. This results in that the microstrip line 46 and the two capacitors 58 and 59 constitutes a low-pass filter 60, wherein a cut-off frequency of the low-pass filter 60 is set to a frequency equal to a sum obtained by adding the transmitting frequency ft to a predetermined margin frequency.

An action of the antenna switching apparatus 305 will be described in detail hereinafter with reference to Fig. 5c.

First of all, in the case where the switch 200 is turned on, namely, a positive direct-current bias voltage is applied to the bias terminal 12, the FET 38 is turned on, and then the impedance between the source and drain electrodes of the FET 38 becomes substantially zero, and then the one end of the microstrip line 46 on the side of the capacitor 39 is electrically connected through the FET 38 of a short-circuit with ground. The phase at another end of the microstrip line 46 is shifted by $\lambda gr/4$ by the microstrip line 46 and thereafter is electrically connected with ground. Therefore, the impedance Zt when seen from the antenna terminal 10 toward the transmitting terminal 9 becomes substantially infinity, and then the transmitting terminal 9 is electrically separated from the antenna terminal 10 while the antenna terminal 10 is electrically connected at the receiving frequency fr with the receiving terminal 11.

On the other hand, in the case where the switch 200 is turned off, namely, the positive direct-current bias voltage is not applied from the battery 201 through the switch 200 to the bias terminal 12, the FET 38 is turned off, and then the impedance between the source and drain electrodes of the FET 38 becomes substantially infinity. Further, as described above, since the air-core inductor 21 is electrically connected as an input coupling component with the connection point P1, the impedance Zr when seen from the connection point P1 or the antenna terminal 10 toward the receiving band-pass filter 8 becomes substantially infinity at the transmitting frequency ft. Therefore, the receiving terminal 11 is electrically separated at the transmitting frequency ft from the antenna terminal 10 while the transmitting terminal 9 is electrically connected with the antenna terminal 10 since the FET 38 is turned off.

The antenna switching apparatus 305 according to the fifth preferred embodiment has the effects similar to those of the fourth preferred embodiment. Further, since the low-pass filter 60 is provided between the connection point P1 and the capacitor 39, unnecessary high-order higher harmonics in the transmitting signal can be sufficiently suppressed.

In the fifth preferred embodiment, the microstrip line 46 are used, however, the present invention is not limited to this. A transmission line such as a strip line, a coplanar line or the like may be used in stead of the microstrip line 46.

SIXTH PREFERRED EMBODIMENT

Fig. 6 is a circuit diagram of an antenna switching apparatus 306 of a sixth preferred embodiment according to the present invention. In Fig. 6, the same components as those shown in Figs. 1a, 1b, 2a, 2b, 2c, 3a, 3b, 4a to 4e, 5a, 5b, 5c and 8 are denoted by the same references as those shown in Figs. 1a, 1b, 2a, 2b, 2c, 3a, 3b 4a to 4e, 5a, 5b, 5c and 8.

As is apparent from comparison between Figs. 1b and 6, the antenna switching apparatus 306 is characterized in further comprising a low-pass filter 61 in addition to the composition of the antenna switching apparatus 301 of the first preferred embodiment shown in Fig. 1b, wherein a cut-off frequency of

the low-pass filter 61 is set to a frequency equal to a sum obtained by adding the transmitting frequency ft to a predetermined margin frequency.

The antenna switching apparatus 306 operates in a manner similar to that of the antenna switching apparatus 301 of the first preferred embodiment, however, since the low-pass filter 61 is further provided between the connection point P1 and the capacitor 9, unnecessary high-order higher harmonics in the transmitting signal can be sufficiently suppressed.

SEVENTH PREFERRED EMBODIMENT

Fig. 7a is a perspective view of an antenna switching apparatus 307 of a seventh preferred embodiment according to the present invention, and Fig. 7b is a circuit diagram of the antenna switching apparatus 307 shown in Fig. 7a. In Figs. 7a and 7b, the same components as those shown in Figs. 1a, 1b, 2a, 2b, 2c, 3a, 3b, 4a to 4e, 5a, 5b, 5c, 6 and 8 are denoted by the same references as those shown in Figs. 1a, 1b, 2a, 2b, 2c, 3a, 3b 4a to 4e, 5a, 5b, 5c, 6 and 8.

As is apparent from comparison between the fourth preferred embodiment shown in Figs. 4a and 4b and the seventh preferred embodiment shown in Figs. 7a and 7b, the antenna switching apparatus 307 has the following features:

(a) the microstrip line 32 is not provided;

(b) a capacitor 40 is provided instead of the capacitor 4; and

(c) there is further electrically connected between the antenna terminal 10 and the capacitor 40, a low-pass filter 62 comprising an inductor 70 and two capacitors 71 and 72 connected with both ends of the inductor 70, wherein the low-pass filter 62 has a cut-off frequency fc equal to a sum obtained by adding a higher frequency among the transmitting and receiving frequencies ft and fr to a predetermined margin frequency in a manner similar to that of the low-pass filter 33 of the third preferred embodiment.

The antenna switching apparatus 307 further has the following features. There are provided laminated two dielectric top and bottom substrates 63a and 63b. Electrically conductive electrode patterns (not shown) are formed on a bottom surface of the top substrate 63b. Electrically conductive electrode patterns 64 and 65 are formed on a top surface of the bottom substrate 63a, wherein the electrode pattern 64 constitutes a microstrip line 46, and also the electrode pattern 65 forms two electrodes for use in the two capacitors 71 and 72 and the microstrip line for use in the inductor 70. Further, an electrically conductive earthed electrode pattern 80 is formed on the whole area of the bottom surface of the bottom substrate 63a. In other words, the antenna switching apparatus 307 is characterized in comprising the electrode patterns 64 and 65 formed on the inner layer of the laminated substrates 63a and 63b.

An action of the antenna switching apparatus 307 will be described in detail hereinafter with reference to Fig. 7b.

First of all, in the case where the switch 200 is turned on, namely, a positive direct-current bias voltage is applied to the bias terminal 12, the FET 38 is turned on, and then the impedance between the source and drain electrodes of the FET 38 becomes substantially zero, and then the one end of the microstrip line 46 on the side of the capacitor 39 is electrically connected through the FET 38 of a short-circuit with ground. The phase at another end of the microstrip line 46 is shifted by $\lambda gr/4$ by the microstrip line 46, and thereafter is electrically connected with ground. Therefore, the impedance Zt when seen from the antenna terminal 10 toward the transmitting terminal 9 becomes substantially infinity, and then the transmitting terminal 9 is electrically separated from the antenna terminal 10 while the antenna terminal 10 is electrically connected at the receiving frequency fr with the receiving terminal 11.

On the other hand, in the case where the switch 200 is turned off, namely, the positive direct-current bias voltage is not applied from the battery 201 through the switch 200 to the bias terminal 12, the FET 38 is turned off, and then the impedance between the source and drain electrodes of the FET 38 becomes substantially infinity. Further, as described above, since the air-core inductor 6 is electrically connected with the connection point P1, the impedance Zr when seen from the connection point P1 toward the receiving band-pass filter 8 becomes substantially infinity at the transmitting frequency ft. Therefore, the receiving terminal 11 is electrically separated at the transmitting frequency ft from the antenna terminal 10 while the transmitting terminal 9 is electrically connected with the antenna terminal 10 since the FET 38 is turned off.

The antenna switching apparatus 307 according to the seventh preferred embodiment has the effects similar to those of the first and fourth preferred embodiments. Further, since the low-pass filter 62 is further provided between the antenna terminal 10 and the capacitor 40, high-order higher harmonics in both the transmitting and receiving signals can be sufficiently suppressed. Furthermore, since the microstrip line 46 and the low-pass filter 62 are formed by the electrode patterns 65 and 66 on the inner layer of the laminated dielectric substrates 63a and 63b, the dimensions of the circuit of the antenna switching

apparatus 307 can be reduced, resulting in the smaller-sized antenna switching apparatus 307.

OTHER PREFERRED EMBODIMENTS

In the above-mentioned preferred embodiments, the plane type dielectric receiving band-pass filter 8 and the dielectric coaxial receiving band-pass filter 23 are used, however, the present invention is not limited to this. For example, there may be used either (a) various kinds of band-pass filters each for passing therethrough the receiving signal having the receiving frequency fr but preventing the transmitting signal from passing therethrough or (b) various kinds of band-stop filters each for stopping the transmitting signal from passing therethrough, such as a SAW (Surface Acoustic Wave) filter or the like.

In the above-mentioned fourth preferred embodiment, the first modification thereof, the fifth and seventh preferred embodiments, the FET 38 is used as a switching device. However, the present invention is not limited to this. A PIN diode may be used in stead of the FET 38.

Although the present invention has been fully described in connection with the preferred embodiments thereof with reference to the accompanying drawings, it is to be noted that various changes and modifications are apparent to those skilled in the art. Such changes and modifications are to be understood as included within the scope of the present invention as defined by the appended claims unless they depart therefrom.

Claims

1. An antenna switching apparatus for selectively connecting an antenna (100) with either a transmitter (101) for transmitting a transmitting signal having a transmitting frequency, or a receiver (102) for receiving a receiving signal having a receiving frequency different from said transmitting frequency, comprising:
   an antenna terminal (10) electrically connected with said antenna (100);
   a transmitting terminal (9) electrically connected with said transmitter (101);
   a receiving terminal (11) electrically connected with said receiver (102);
   a receiving filter (8, 23), electrically connected between said antenna terminal (10) and said receiving terminal (11), for passing therethrough a receiving signal;
   an impedance adjusting element (6, 21, 32) electrically connected with an input end of said receiving filter (8, 23), said impedance adjusting element (6, 21, 32) having such an element value that an impedance when seen from said antenna terminal (10) toward said receiving filter (8, 23) becomes substantially infinity at said transmitting frequency; and
   a switching device (1, 38a, 46 and 38) electrically connected between said antenna terminal (10) and said transmitting terminal (9), said switching device (1, 38a, 46 and 38a) being switched over in response to a control signal so that an impedance when seen from said antenna terminal (10) toward said transmitting terminal (9) becomes either substantially infinity or substantially zero.

2. The antenna switching apparatus as claimed in Claim 1,
   wherein said impedance adjusting element is an inductor (6) electrically connected between the input end of said receiving filter (8, 23) and ground.

3. The antenna switching apparatus as claimed in Claim 1,
   wherein said impedance adjusting element is an inductor (21) electrically connected between the input end of said receiving filter (8, 23) and said antenna terminal (10).

4. The antenna switching apparatus as claimed in Claim 1,
   wherein said impedance adjusting element is a transmission line (32) connected between the input end of said receiving filter (8, 23) and said antenna terminal (10), said transmission line (32) having such a length ($\ell e1$) that an impedance when seen from said antenna terminal (10) toward said receiving filter (8, 23) becomes substantially infinity at said transmitting frequency.

5. The antenna switching apparatus as claimed in any one of Claims 1 to 4, further comprising a low-pass filter (33, 62) electrically connected between said antenna terminal (10) and said receiving filter (8, 23), said low-pass filter (33, 62) having a cut-off frequency equal to a sum obtained by adding a higher frequency among said transmitting and receiving frequencies to a predetermined margin frequency.

6. The antenna switching apparatus as claimed in any one of Claims 1 to 4, further comprising a low-pass filter (46) electrically connected between said antenna terminal (10) and said switching device (1, 38a, 46 and 38), said low-pass filter (46) having a cut-off frequency equal to a sum obtained by adding said transmitting frequency to a predetermined margin frequency.

7. The antenna switching apparatus as claimed in any one of Claims 1 to 4, further comprising a low-pass filter (61) electrically connected between said transmitting terminal (9) and said switching device (1, 38a, 46 and 38), said low-pass filter (61) having a cut-off frequency equal to a sum obtained by adding said transmitting frequency to a predetermined margin frequency.

8. The antenna switching apparatus as claimed in any one of Claims 1 to 7,
wherein said switching device is a PIN diode (1).

9. The antenna switching apparatus as claimed in any one of Claims 1 to 7,
wherein said switching device is an field effect transistor (38a).

10. The antenna switching apparatus as claimed in any one of Claims 1 to 7,
wherein said switching device includes:
a further transmission line (46) electrically connected between said antenna terminal (10) and said transmitting terminal (9), said further transmission line (46) having a length of a quarter of the guide wavelength of the receiving frequency; and
a switching component (38) electrically connected between said transmitting terminal (9) and ground, said switching component (38) being turned on or off in response to said control signal, thereby switching over so that the impedance when seen from said antenna terminal (10) toward said transmitting terminal (9) becomes either substantially infinity or substantially zero, respectively.

Fig.1a

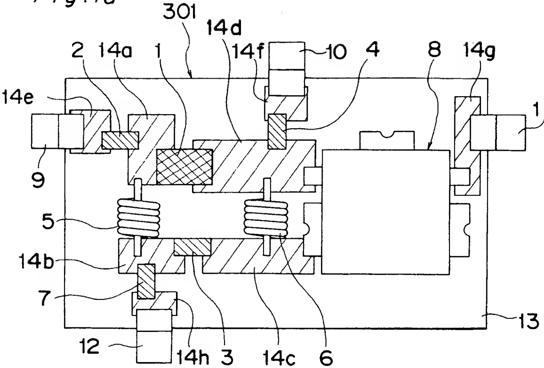

301
14d
2
14a
1
14f
10
4
8
14g
14e
11
9
5
14b
7
13
12
14h
3
14c
6

Fig.1b

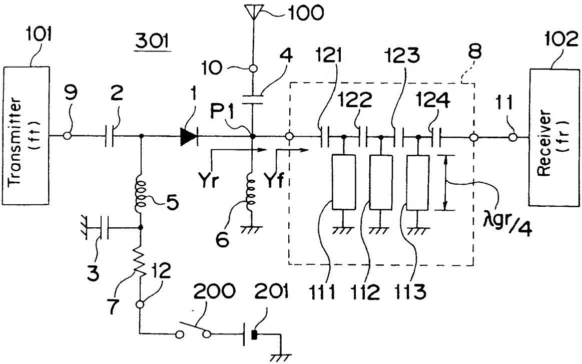

100
101
301
102
10
4
121
123
8
9
2
1
P1
122
124
11
Transmitter (ft)
Receiver (fr)
Yr
Yf
5
6
λgr/4
3
12
7
200
201
111
112
113

Fig.2a

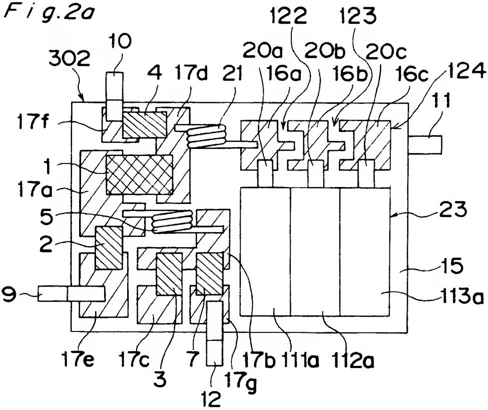
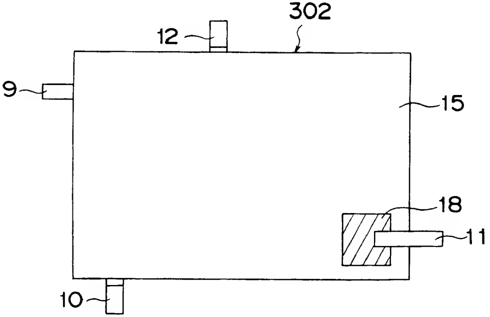
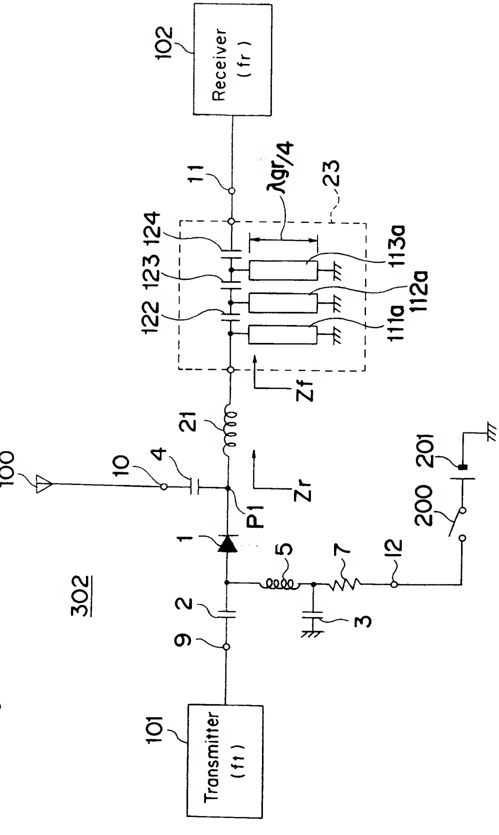

302
10
4
17d
21
20a
16a
122
20b
16b
123
20c
16c
124
11
17f
1
17a
5
2
9
23
15
113a
17e
17c
3
7
12
17g
17b
111a
112a

Fig.2b


302
12
9
15
18
11
10



302
Transmitter (ft)
101
9
2
3
5
7
12
1
P1
4
10
100
200
201
Zr
21
Zf
23
122
123
124
111a
112a
113a
λgr/4
11
Receiver (fr)
102

Fig. 2c

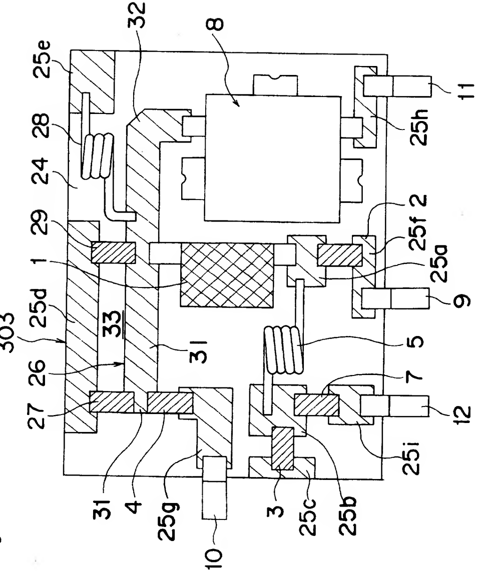

25e
32
8
28
24
29
1
25d
303
33
26
27
31
4
25g
10
3
25c
25b
11
25h
2
25f
25a
9
5
7
12
25i

Fig.3a

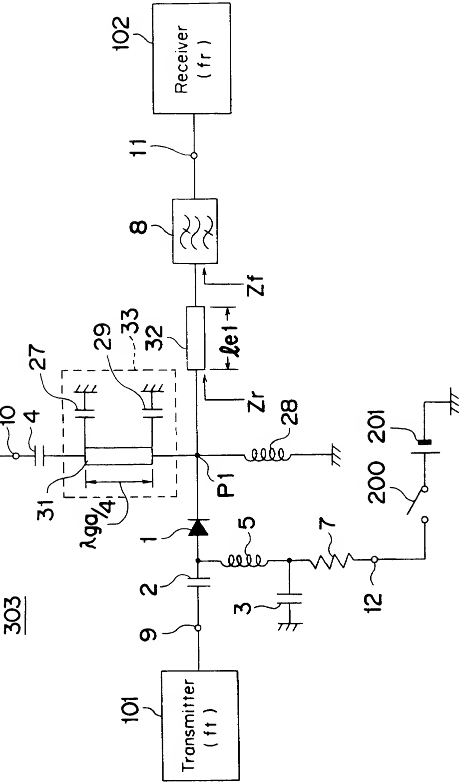

303
Transmitter
(ft)
101
Receiver
(fr)
102
100
10
4
27
29
33
32
31
λga/4
ℓe1
Zr
Zf
P1
28
1
2
3
5
7
8
9
11
12
200
201

Fig.3b

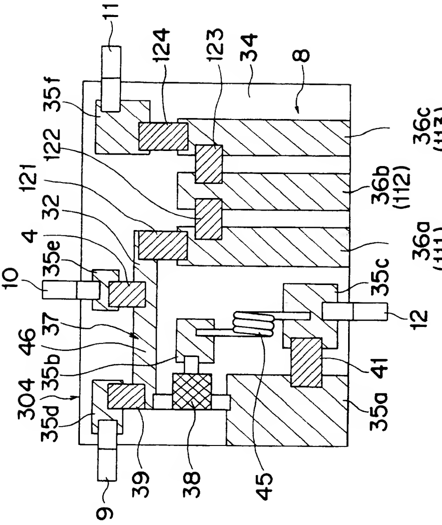
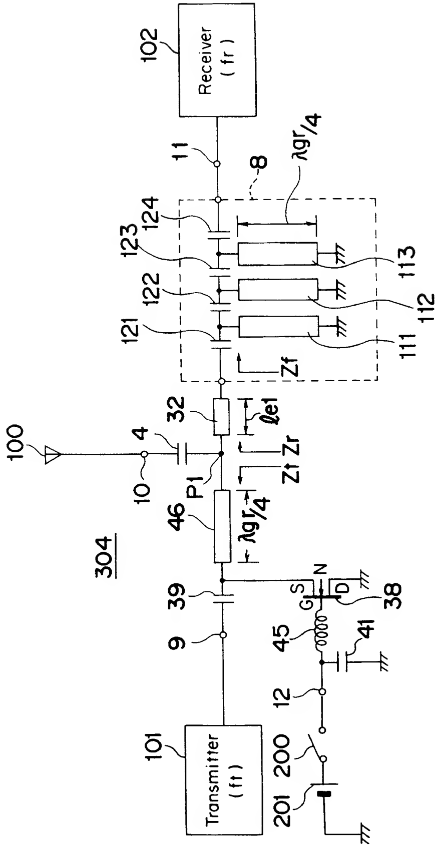

11
124
123
34
8
35f
122
121
32
4
35e
10
37
46
35b
304
35d
9
39
38
45
36c
(113)
36b
(112)
36a
(111)
35c
12
41
35a

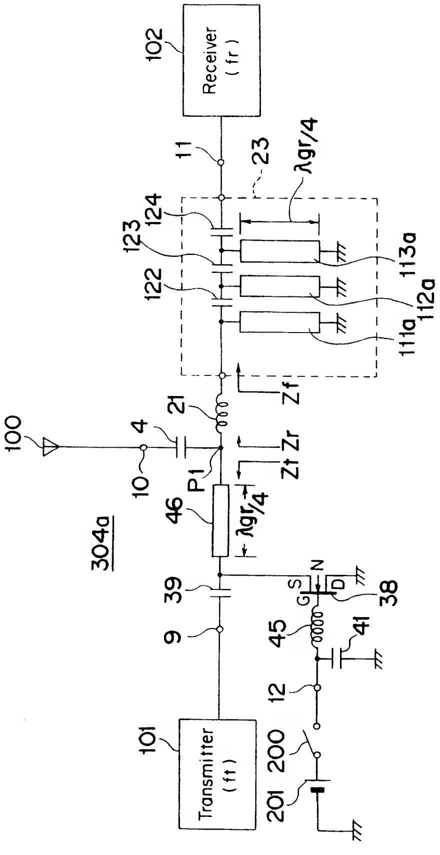
Fig. 4a



Receiver
(fr)
102
11
8
λgr/4
124
123
122
121
113
112
111
Zf
32
ℓe1
Zr
Zt
100
4
10
P1
46
λgr/4
304
39
N
S
D
G
38
9
45
41
12
101
Transmitter
(ft)
200
201

Fig.4b

Fig. 4c


Receiver
(fr)
102
11
23
λgr/4
124
123
122
113a
112a
111a
Zf
21
100
4
10
Zr
Zt
P1
46
λgr/4
304a
39
S
N
G
D
38
9
45
41
12
101
Transmitter
(ft)
200
201

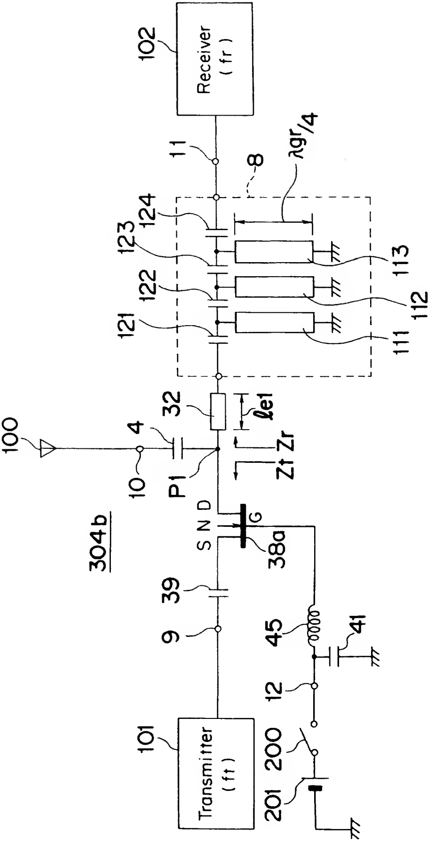

Receiver
(fr)
102
11
8
λgr/4
124
123
122
121
113
112
111
32
ℓe1
Zr
Zt
100
4
10
P1
S N D
G
38a
304b
39
9
45
41
12
101
Transmitter
(ft)
200
201

Fig.4d

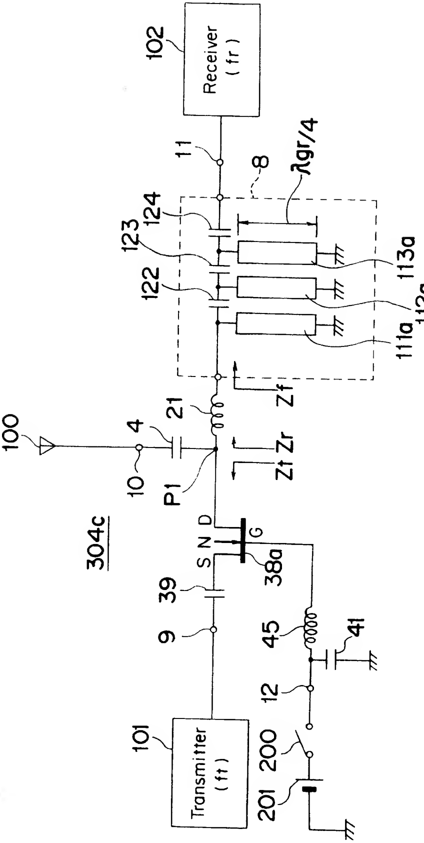
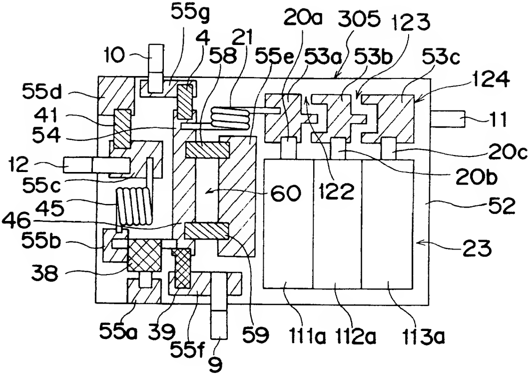

102
Receiver
(fr)
11
8
λgr/4
124
123
122
113a
112a
111a
Zf
100
4
21
10
Zt
Zr
P1
304c
D
N
S
G
38a
39
9
45
41
12
101
Transmitter
(ft)
200
201

Fig. 4e

Fig.5a


55g
20a
305
123
10
4
21
58
55e
53a
53b
53c
124
55d
11
41
54
20c
12
20b
55c
60
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46
55b
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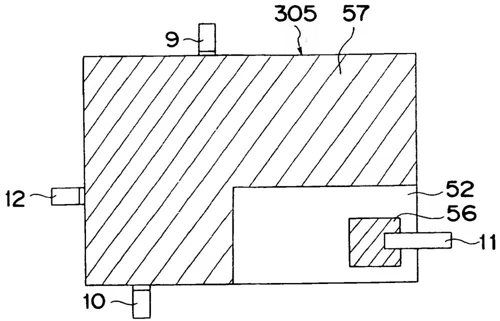
55a
39
55f
59
111a
112a
113a
9

Fig.5b


305
57
9
52
12
56
11
10

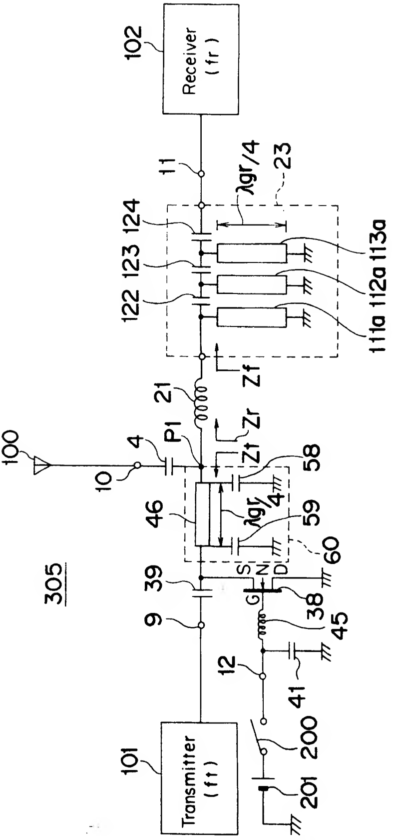

305
Receiver (fr)
Transmitter (ft)
102
101
100
11
10
9
4
P1
Zr
Zt
Zf
21
23
λgr/4
124
123
122
111a
112a
113a
46
58
59
60
39
38
S
N
D
G
45
41
12
200
201

Fig.5c

Fig.6

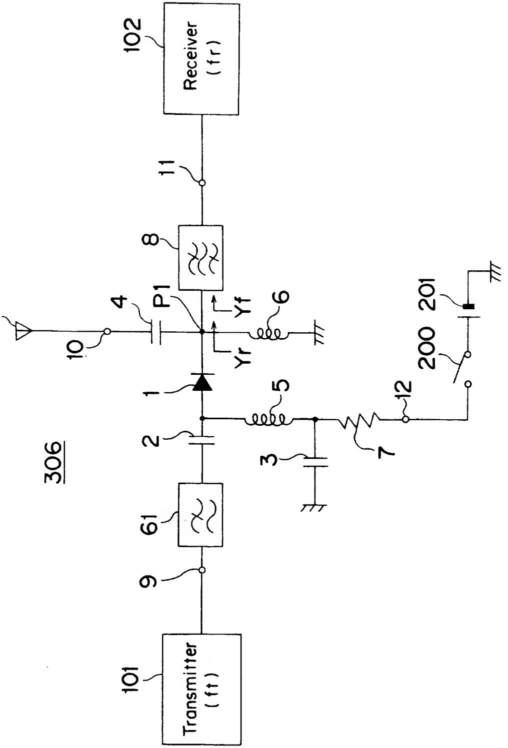
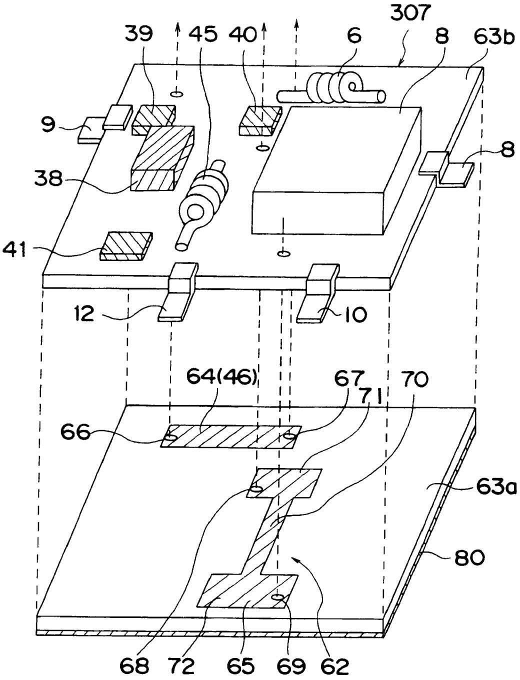

306
Transmitter
(ft)
101
9
61
2
3
1
5
7
12
200
201
10
100
4
P1
Yr
Yf
6
8
11
Receiver
(fr)
102

Fig.7a


307
39
45
40
6
8
63b
9
8
38
41
12
10
64(46)
67
71
70
66
63a
80
68
72
65
69
62

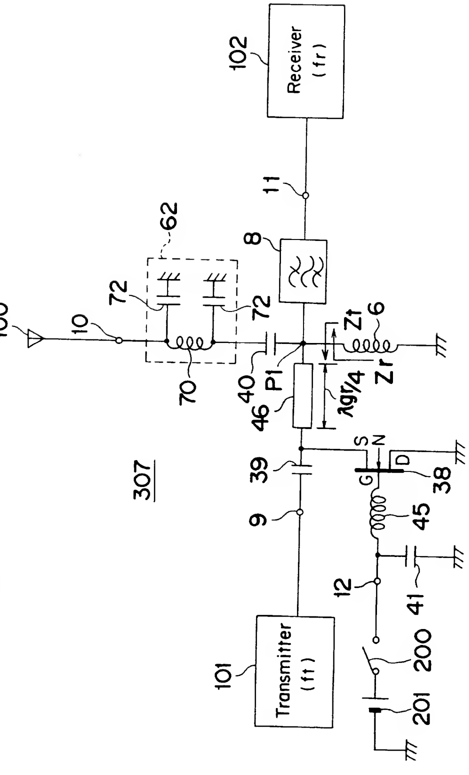
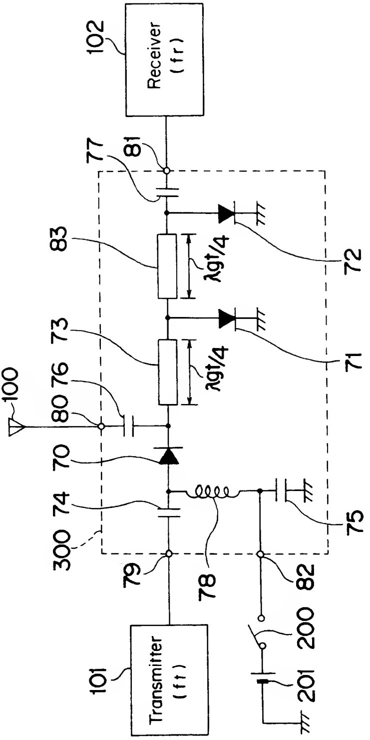

307
100
10
62
72
72
70
40
P1
46
λgr/4
Zt
Zr
6
8
11
102
Receiver
(fr)
39
9
S
N
G
D
38
45
41
12
200
201
101
Transmitter
(ft)

Fig.7b

Fig.8 PRIOR ART



European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 93 11 0677

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	US-A-5 023 866 (DEMURO) * column 3, line 19 - line 41 * * column 5, line 23 - column 7, line 2; figures 1,6 *	1,4	H01Q1/00 H01P1/15
A	IEICE TRANSACTIONS vol. E74, no. 6, June 1991, TOKYO JP pages 1556 - 1562 T. NISHIKAWA 'RF front end circuit components miniaturized using dielectric resonators for cellular portable telephones' * page 1557, left column, line 1 - right column, line 9; figure 2 *	1,2	
A	GB-A-1 149 043 (RADIO CORPORATION OF AMERICA) * the whole document *	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

H01P
G01S
H01Q

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	18 OCTOBER 1993	DEN OTTER A.M.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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